

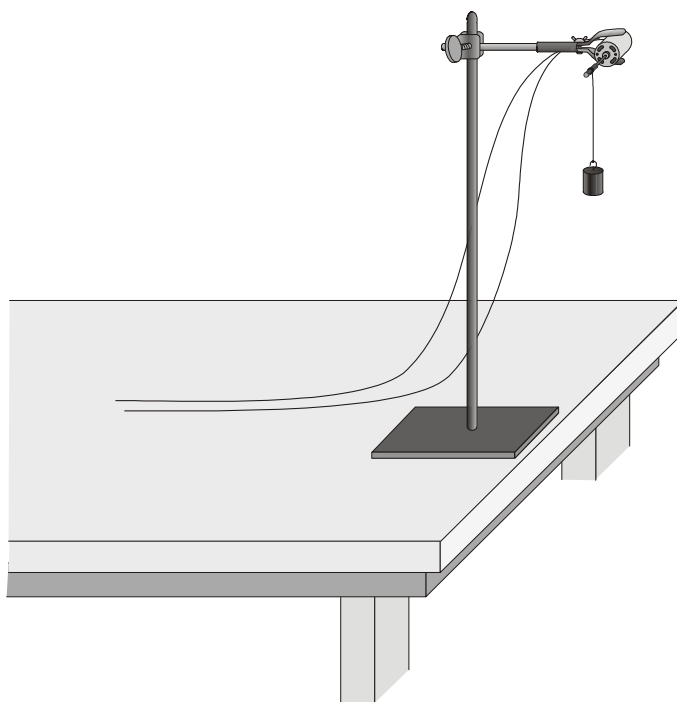
# Electrical Energy

In this experiment, you will study a small, inexpensive electric motor used as a crude elevator. You will measure the current through, and voltage across, a motor as it lifts a small mass. If you know the current and voltage, you can calculate another electrical quantity – *power*. The power used by an electrical device can be calculated from

$$\text{power} = \text{current} \times \text{voltage}$$

The unit of power is the watt (W). An electrical device that has a power of 1 W converts one joule of energy to another form every second (1 J/s). If the power provided to a device is constant over time, you can multiply the power by the time and get the energy. If the power provided to a device changes during the experiment, the electrical energy can be determined by finding the area under a power vs. time graph.

You will use this approach to determine the electrical energy used by the motor and compare it to the change in gravitational potential energy of the mass. The gravitational potential energy gained by an object can be calculated if you know the mass and the distance it is lifted. By comparing the electrical energy supplied to the motor with the gain in potential energy of the mass you can calculate the efficiency of the motor as a machine used for lifting.



*Figure 1*

## OBJECTIVES

- Measure the power and electrical energy used by an electric motor.
- Measure the gain in potential energy of a mass lifted by the motor
- Calculate the efficiency of the motor.
- Study the efficiency of the electric motor under different conditions.

## Experiment 30

### MATERIALS

Power Macintosh or Windows PC	wires
LabPro or Universal Lab Interface	clips to hold wires
Logger <i>Pro</i>	electric motor
Vernier Current & Voltage Probe System	mass set
adjustable-voltage DC power supply	string
ring stand	utility clamp
small, wooden dowel rod	

### SETUP AND PRELIMINARY QUESTIONS

1. Open the file in the Experiment 30 folder of *Physics with Computers*. Three graphs will appear on the screen: voltage (0-6 V), current (0-0.6 A) and power (0-2 W) plotted vs. time. The experiment length is set for 30 s.

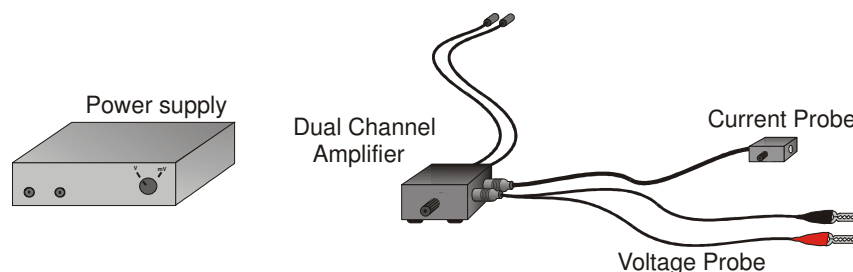


Figure 2

2. Connect DIN 1 plug from the Dual-Channel Amplifier to Channel 1 of the LabPro or Universal Lab Interface. Connect DIN 2 plug to Channel 2. Connect a Voltage Probe to PROBE 1 on the Dual-Channel Amplifier. Connect a Current Probe to PROBE 2.
3. Set up the motor apparatus as shown in Figure 1. There should be an axle on your motor where the string can be wound as the mass is lifted. Allow room for the mass to be lifted at least 0.5 m; a longer distance would be better. Make a loop at the end of the string for connecting the mass.
4. Connect the circuit as shown. Take care that the positive (red) lead of the Voltage Probe and the red terminal from the Current Probe are oriented toward the + terminal.
5. With the power supply off, click , then click .

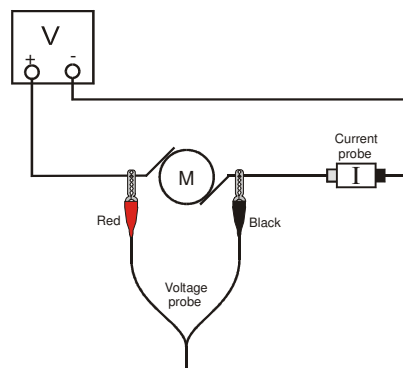




Figure 3

6. Set the voltage control on your power supply to 0 V. Turn on the power supply and gradually increase the voltage setting. Watch the motor to see when it starts to turn slowly. Control the voltage so that the motor turns slowly and lifts the mass slowly. Set the control to 0 V when the mass reaches the top.
7. Explain the energy changes that take place as the mass is lifted.

8. Without making any measurements, make a guess of what you would expect for the efficiency of this electric motor; that is, guess the percentage of the electrical energy that goes into lifting and the fraction that is wasted as heat.

## PROCEDURE

1. Check the voltage rating of your motor. This is the maximum voltage you should use. If you are not sure of the rating, ask your instructor. Record the voltage rating in the data table.
2. Make sure the power supply is set to 0 V. Place a 10-g mass at the end of the string as the load to be lifted. Click  to begin data collection. Turn on the power supply and gradually increase the voltage setting. Watch the motor to see when it starts to turn slowly. Control the voltage so that the motor turns slowly and lifts the mass. The goal here is to get a graph of voltage and current readings for the complete process of lifting the mass from the low point all the way to the top. You have 30s to make the lift. If necessary, repeat this step until you get a good run.
3. On the power vs. time graph, drag the mouse over the region when the mass was being lifted. Click on the Integrate button, . The area under the power vs. time graph will be displayed in a floating box.  
**Note:** The area, or integral, value has units of W-s, or J. Record this value in the data table.
4. Increase the load by 10 g and repeat Steps 2 – 3. Again, make sure you get voltage and current data for the entire lift. Note the mass used in each run in the data table below.
5. Repeat Steps 2 – 4 until the motor will not lift the load without exceeding its voltage rating.

## DATA TABLE

Distance Mass was lifted (m)	
Voltage rating of motor (V)	

Run	Load Lifted (g)	Electrical Energy Used (J)	Mechanical Energy Output (J)	Percent Efficiency (%)
1				
2				
3				
4				
5				
6				
7				

## ANALYSIS

1. For each experimental run, calculate the increase in gravitational potential energy of the mass and record it in the data table.
2. For each run, calculate the efficiency of the motor; that is, what percentage of the electrical energy into the motor was converted to gravitational potential energy? Record your answer in the data table.
3. For which load was the motor most efficient?
4. What happened to the remainder of the electrical energy that went to the motor?

**DO ONE OF THE FOLLOWING EXTENSIONS (WRITE A PARAGRAPH OF CONCLUSIONS AND SHOW GRAPHS)**

1. Plot a graph of the efficiency of the motor as a function of the load. Print or sketch a copy of the graph.
2. Investigate the efficiency of the motor at different speeds using the same load.
3. Try other motors and see if you can find more efficient ones.
4. Use a temperature probe to monitor the temperature change of the motor.

**Write a summary of the concepts you learned about in this lab.**